AF

Attorney Docket No. Patent 015290-506 RFW

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Patent Application of

Ting Chien et al.

Application No.: 09/820,692

Filing Date: March 30, 2001

Group Art Unit: 1765

Examiner: KIN CHAN CHEN

Confirmation No.: 5245

Title: PLASMA ETCHING OF DIELECTRIC LAYER WITH SELECTIVITY TO STOP LAYER

## AMENDMENT/REPLY TRANSMITTAL LETTER

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Enclosed is a reply for the above-identified patent application.

☐ A Petition for Extension of Time is also enclosed.

☐ Terminal Disclaimer(s) and the ☐ $65.00 (2814) ☐ $130.00 (1814) fee per Disclaimer due under 37 C.F.R. § 1.20(d) are also enclosed.

☒ Also enclosed is/are Reply Brief _____

☐ Small entity status is hereby claimed.

☐ Applicant(s) requests continued examination under 37 C.F.R. § 1.114 and enclose the ☐ $395.00 (2801) ☐ $790.00 (1801) fee due under 37 C.F.R. § 1.17(e).

☐ Applicant(s) requests that any previously unentered after final amendments not be entered. Continued examination is requested based on the enclosed documents identified above.

☐ Applicant(s) previously submitted _____

on _____,
for which continued examination is requested.

☐ Applicant(s) requests suspension of action by the Office until at least _____, which does not exceed three months from the filing of this RCE, in accordance with 37 C.F.R. § 1.103(c). The required fee under 37 C.F.R. § 1.17(i) is enclosed.

☐ A Request for Entry and Consideration of Submission under 37 C.F.R. § 1.129(a) (1809/2809) is also enclosed.

☐ No additional claim fee is required.

☐ An additional claim fee is required, and is calculated as shown below.

| AMENDED CLAIMS | | | | | |
|---|---|---|---|---|---|
| | **No. of Claims** | **Highest No. of Claims Previously Paid For** | **Extra Claims** | **Rate** | **Additional Fee** |
| Total Claims | | MINUS = | 0 | x $50.00 (1202) = | $ 0.00 |
| Independent Claims | | MINUS = | 0 | x $200.00 (1201) = | $ 0.00 |
| If Amendment adds multiple dependent claims, add $360.00 (1203) | | | | | |
| Total Claim Amendment Fee | | | | | $ 0.00 |
| ☐ Small Entity Status claimed - subtract 50% of Total Claim Amendment Fee | | | | | $ 0.00 |
| **TOTAL ADDITIONAL CLAIM FEE DUE FOR THIS AMENDMENT** | | | | | **$ 0.00** |

☐ A check in the amount of _____ is enclosed for the fee due.

☐ Charge _____ to Deposit Account No. 02-4800.

☐ Charge _____ to credit card. Form PTO-2038 is attached.

The Director is hereby authorized to charge any appropriate fees under 37 C.F.R. §§ 1.16, 1.17, 1.20(d) and 1.21 that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800. This paper is submitted in duplicate.

Respectfully submitted,

BUCHANAN INGERSOLL PC

By _____
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Date: October 21, 2005

Attorney's Docket No. 015290-506

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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|---|---|
| In re Patent Application of | **Mail Stop APPEAL BRIEF - PATENTS** |
| Ting Chien et al. | Group Art Unit: 1765 |
| Application No.: 09/820,692 | Examiner: KIN CHAN CHEN |
| Filed: March 30, 2001 | Confirmation No.: 5245 |
| For: PLASMA ETCHING OF DIELECTRIC LAYER WITH SELECTIVITY TO STOP LAYER | Appeal No.: |

## REPLY BRIEF

**Mail Stop APPEAL BRIEF - PATENTS**
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Appellants hereby reply to positions taken in the Examiner's Answer mailed August 23, 2005.

I. **Rejection of Independent Claims 1, 24, and 25 under 35 U.S.C. § 103(a)**

A. **Lack of Suggestion or Motivation Renders Prior Art Combination Improper**

In order to establish a case of *prima facie* obviousness with respect to claimed subject matter, the Patent Office must establish (1) "some suggestion or motivation in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to ... combine the reference teachings"; (2) "a reasonable expectation of success"; and that (3) "the prior art ... references when combined ... must teach or suggest all the claim limitations." "The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure" (citation omitted). *See* MPEP §§ 2143 and 2143.03.

The Advisory Action asserts, "In this case, [the teaching, suggestion, or motivation to combine or modify the teachings of the prior art to produce the claimed invention is found] in the knowledge generally available to one of ordinary skill in the

art because it is [a] notoriously well-known feature in the art." (Advisory Action at Page 2). As explained below, dielectric etching with a dual frequency capacitively coupled plasma reactor was not known until Appellants' invention.

The proposed combination of Liu and Schmitt is presented in the final Official Action as follows,

> Liu teaches using capacitively coupled plasma reactor including an upper showerhead electrode and a bottom electrode. The claimed invention differs from Liu by specifying a dual frequency capacitively coupled plasma reactor including an upper showerhead electrode and a bottom electrode. Schmitt is relied only to show the well-known feature such as dual frequency capacitively coupled plasma reactor including an upper showerhead electrode and a bottom electrode as claimed... Hence, it would have been obvious to one with ordinary skill in the art to incorporate those features as disclosed by Schmitt in the process of Liu in order to separately control the upper electrode and lower (bottom) electrode. (Final Official Action at Page 3).

The Examiner is incorrect in holding that Liu teaches using a showerhead ***electrode*** (see Examiner's Answer at page 6, lines 9-10, and page 7, lines 4-5). As noted in the Appeal Brief, Liu discloses use of a ***quartz*** gas distribution plate through which process gas is supplied to the interior of the reactor. Specifically,

> Processing gases are supplied from gas sources 58, 60, 62 through respective mass flow controllers 64, 66, 68 to a quartz gas distribution plate 70 positioned in the roof of the chamber 32 overlying the wafer 34 and separated from it across a processing region 72. ... The distribution plate 70 includes a manifold 74 receiving the processing gas and communicating with the processing region 72 through a showerhead having a large number of distributed apertures 76 so as to inject a more uniform flow of processing gas into the processing region 72. (Column 4, Lines 34-45, of Liu).

Liu further discloses, "An RF power supply 42, preferably operating at 13.56 MHz, is connected to the cathode pedestal 38 and provides the only significant power for generating the plasma while also controlling the DC self-bias." (Column 4, Lines 22-25). Thus, the plate 70 of Liu is not an electrode.

Column 7, line 67 – column 8, line 8, of Schmitt disclose,

> The reactor 20 is fed with two different driving energy sources : a RF high frequency source (higher than 30 MHz) and a RF bias source 93 (lower than 15 MHz). The upper "shower head" electrode 3 is connected to the high frequency source 91 and the low electrode 45 is connected to the RF bias source 93. One of the sources is meant to provide the plasma . . . .

A gas distribution plate could only be considered an "electrode" if power is supplied to it or it acts as a return path if power is supplied to the bottom electrode.[1] Specifically, Schmitt discloses connecting a showerhead electrode to an RF high frequency source to provide plasma. In contrast, Liu discloses a ***quartz*** gas distribution plate and the power source in Liu is the cathode pedestal used to generate plasma. Quartz is a well-known insulating material, rather than an electrically conductive material. Accordingly, the ***quartz*** distribution plate of Liu is not a showerhead ***electrode***, as power could not be applied to it, in order to generate plasma.

In view of the above, the Examiner's position that Liu uses a showerhead electrode is clearly in error. Accordingly, the Examiner's position that it would have been obvious to incorporate dual frequency as disclosed by Schmitt into the MERIE reactor of Liu including a quartz distribution plate in order to separately control the upper electrode and lower (bottom) electrode is untenable.

With regard to Liu's focus on a MERIE reactor, the Examiner has asserted, "Magnetical enhancement feature is simply an added feature to the apparatus whenever there is a need for the process." (Final Official Action at Page 5). Appellants respectfully disagree since in Liu, use of a MERIE reactor is an essential

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[1] See, for example, U.S. Patent No. 6,477,980, assigned to Applied Materials, Inc. (the assignee of Liu), which explains that a gas distribution plate must be composed of an electrically conductive material in order to function as an electrode, as a power supply is connected to the gas distribution plate. ("The gas distribution plate or diffuser plate 20 is composed of an electrically conductive material, preferably aluminum, so that it can function as an anode electrode. An RF power supply, not shown, is connected between the gas distribution plate and the electrically grounded chamber components." (Column 3, Lines 31-35, of U.S. Patent No. 6,477,980))

component of the process. In particular, Liu explains the need for magnetic enhancement as follows,

> [A] high-density plasma tends to produce hot electrons, and those escaping the plasma are likely to implant themselves well within the insulative photoresist, thereby negatively charging it. The trapped negative charge then accelerates the positively charged ions from the plasma to the photoresist. Such high-energy ions will sputter the photoresist. On the other hand, MERIE plasmas tend to produce a significantly lower electron temperature, thereby reducing the charging effect.
>
> * * * The magnetic field increases the plasma density without increasing the DC bias such as would occur if increasing RF power were used to increase the plasma density. The magnetic field also strongly influences the process gas cracking sequence and therefore the final plasma composition. The magnetic field also makes it possible to run the process using a higher RF power for higher oxide etch rate without sacrificing a reasonably low DC bias. Increased magnetic field has the effect of reducing the DC self-bias on the pedestal, and thus reducing the ion bombardment energy. The effect is complicated and involves the interaction of the magnetic and electric fields. Fundamentally, the magnetic field more closely confines the plasma and increases its density. The higher plasma density impresses more current in the equivalent electrical circuit of the plasma for a fixed input power and thus reduces the sheath voltage. That is, the high plasma density reduces the self-bias voltage. The reduced DC bias reduces the photoresist corner loss catalyzed by high-energy ion bombardment and therefore increases the photoresist selectivity with respect to the facet.
>
> * * *
>
> The variable magnetic field provided by a magnetic field induced by an electrical coil rather than permanent magnets allows superior adjustability of the magnetic field strength to be used as an effective process tuning knob for controlling the plasma composition by controlling the degree of dissociation. A wider range of tunability of all of the process parameters is achieved by maintaining the plasma density between $10^9$ to $10^{11}/cm^3$ with the desired

> plasma composition for high aspect-ratio contact and via etch and various other special applications. (Column 6, Line 28 – Column 7, Line 18).

Further,

> Based upon the above described concepts, this invention utilizes the intrinsic advantage of these low F/C-ratio gases, combines the superior working conditions, including proper plasma density, adjustable magnetic field, and short residence time provided by an advanced MERIE chamber to tune the plasma composition and thus to obtain desirable polymerization for various critical dielectric etch applications. (Column 7, Lines 55-62).

Thus, as disclosed by Liu, the invention of Liu utilizes and requires magnetic enhancement to appropriately tune the plasma composition and thus obtain desirable polymerization. This necessarily excludes use of an electrode as the showerhead.

The Examiner's Answer contends, "The system of Schmitt is capable of etching various materials, see col. 1, lines 1-40. Since Liu teaches etching dielectric oxide, the combined prior art teaches etching dielectric oxide." (Page 6 of Examiner's Answer). Schmitt, however, "relates to a capacitively coupled radiofrequency (RF) plasma reactor and to a process for treating at least one substrate in such a reactor." (Column 1, Lines 7-9). Schmitt discloses,

> Various processes are used to modify the nature of the substrate surface. Depending on the process and in particular the nature of the gas injected in the glow discharge, the substrate properties can be modified (adhesion, wetting), a thin film added (chemical vapour deposition CVD, diode sputtering) or another thin film selectively removed (dry etching). (Column 1, Lines 17-23).

Schmitt discloses wafers, polymer, glass, foil, plastic and metal as substrate types. (See Table 1 in Column 1). Schmitt further discloses that the substrate can be a dielectric plate of uniform thickness or that the substrate can be a dielectric member.

(See, for example, Column 5, Lines 3-4 and Column 7, Lines 59-60).[2] It is respectfully submitted that as Schmitt discloses both numerous substrates, reactors, and processes, and as there is no mention in Schmitt of substrates having layers of dielectric oxide or of etching dielectric oxide layers with selectivity to an under layer, the final Official Action fails to establish the required motivation which would have led a person of ordinary skill in the art to consider Schmitt for purposes of modifying the dielectric oxide etch process of Liu. Given Liu's teachings to avoid use of an electrode for the showerhead, only through impermissible hindsight would one of ordinary skill combine Schmitt with Liu.

Without knowledge of the claimed process, there is no objective teaching in the prior art which would have led one of ordinary skill in the art to combine Liu and Schmitt in the manner set forth in the final Official Action. That is, the final Official Action fails to establish any motivation for substituting a "dual frequency" showerhead electrode (one of several reactor designs in Schmitt) and all of the electronic modification that would be required[3] for the quartz gas distribution plate in the MERIE reactor of Liu. As such, the rejection is improper and should be reversed.

Schmitt discloses various reactors for a multitude of purposes but the primary thrust of Schmitt is the use of a dielectric material as part of a pedestal as a capacitor in series with a substrate and plasma. Fig. 2 shows a reactor 1 having two spaced apart metallic electrodes 3, 5 neither of which is a showerhead electrode since gas is supplied from a side of the reactor 1 by gas source 7. (See Column 21, Lines 54-60 and Fig. 2 of Schmitt). Fig. 10 shows a reactor having a showerhead electrode 3 and Fig. 12 shows a microwave reactor having a bottom electrode 126 but no showerhead electrode. Liu fails to disclose a showerhead electrode and Schmitt only discloses a showerhead electrode in one of the three reactors shown therein. At most, the final Official Action bases the rejection on an impermissible

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[2] To the extent the Appeal Brief characterized Schmitt as only disclosing dielectric in connection with the corrective layer of Schmitt, the foregoing discussion of Schmitt is intended to clarify Appellants' position on this point, *i.e.*, Schmitt also discloses dielectric substrates.

[3] As explained below, replacing the quartz showerhead with a showerhead electrode would require substantial reconstruction and the assignee of Liu obtained a later patent where a showerhead electrode was incorporated in a MERIE reactor.

"obvious to try" standard rather than the required objective teaching in the prior art. As such, the combination of Liu and Schmitt fails to suggest the process recited in Claim 1 using a dual frequency capacitively coupled plasma reactor wherein etchant gas is supplied to the chamber with a showerhead electrode and RF energy is supplied at two different frequencies to either a bottom electrode or at different frequencies to the showerhead electrode and the bottom electrode.

As noted above, rather than disclosing a showerhead electrode, Liu actually discloses a quartz gas distribution plate. Replacement of the quartz gas distribution plate of Liu with a showerhead electrode goes against the teachings of Liu and would require substantial reconstruction of Liu. In particular, referring to FIG. 2, as noted above, Liu discloses, "An RF power supply 42, preferably operating at 13.56 MHz, is connected to the cathode pedestal 38 and provides the only significant power for generating the plasma while also controlling the DC self-bias." (Column 4, Lines 22-25). According to FIG. 2 of Liu, the RF power is returned through the chamber side walls. Thus, replacing the quartz gas distribution plate with a showerhead electrode would change the principle of operation of the Liu reactor and require substantial modification of the reactor to avoid problems such as arcing within the gas injection ports.

Incorporation of a showerhead electrode in a MERIE reactor is the subject of U.S. Patent No. 6,894,245 ("Hoffman", assigned to Applied Materials, Inc., the assignee of Liu), filed October 22, 2001, which is seven (7) months after Appellants' filing date. Hoffman discloses a plasma reactor for processing a semiconductor workpiece, which includes a reactor chamber having a chamber wall and containing a workpiece support for holding the semiconductor workpiece, an overhead electrode overlying said workpiece support, the electrode comprising a portion of the chamber wall, an RF power generator for supplying power at a frequency of the generator to the overhead electrode and capable of maintaining a plasma within the chamber at a desired plasma ion density level. The reactor further includes a set of MERIE magnets surrounding the plasma process area overlying the wafer surface that produce a slowly circulating magnetic field which stirs the plasma to improve plasma ion density distribution uniformity. (Column 2, Lines 48-66).

Hoffman discloses that an MERIE reactor: (1) "is, typically, a capacitively coupled reactor in which HF frequency RF source power is applied to the wafer support pedestal and returned through the chamber ceiling or side walls," (Column 16, Lines 5-9) and (2) "requires the process gases to be fed from an overhead gas distribution plate or showerhead."[4] (Column 17, Lines 41-43). As noted above, Liu discloses that the overhead gas distribution plate or showerhead is made of a non-conductive material, and Hoffman further discloses that in order to achieve the desired combination of a showerhead electrode with an MERIE reactor, the problem of the susceptibility of the capacitively coupled reactor of Hoffman to arcing within the gas injection ports in the gas distribution plate had to be solved. (Column 17, Lines 47-53).

Additionally, with regard to the contention in the Advisory Action that apparatus limitations do not have weight in a process claim, unless they affect the process in a manipulative sense, as is evident from Hoffman, the presently claimed apparatus limitations do affect the processes of independent Claims 1, 24, and 25 in a manipulative sense. In particular, Hoffman discloses that arcing and other potential issues are avoided though any of a combination of features, including putting the overhead electrode at a floating D.C. potential by capacitively isolating it from the coaxial tuning stub, providing capacitance between the plasma and the overhead electrode, and introducing a metal or ceramic "foam" layer between the coaxial stub and the capacitive layer lying between the electrode and the coaxial tuning stub. (Column 19, Lines 11-55).

Hoffman establishes that conversion of a MERIE reactor to one with an upper electrode requires substantial reconstruction and redesign of the MERIE reactor, so much that Hoffman was awarded a patent for the new combination. Because the new combination of a MERIE reactor with a showerhead electrode did not exist at the time of Appellants' filing date, it is respectfully submitted that the modification of Liu proposed in the final Official Action would not have been obvious to a person or ordinary skill in the art at the time of Appellants' invention.

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[4] Such a "showerhead" is not an electrode.

B. **Lack of Reasonable Expectation of Success Renders Prior Art Combination Improper**

Whether an art is predictable or whether the proposed modification or combination of the prior art has a reasonable expectation of success is determined at the time the invention was made. *Ex parte Erlich*, 3 USPQ2d 1011 (Bd. Pat. App. & Inter. 1986); MPEP § 2143.02.

In light of the later disclosure in Hoffman, specifically regarding solving the problem of the susceptibility of arcing within the gas injection ports in an electrically conductive gas distribution plate, it is respectfully submitted that the proposed selective incorporation of only the dual frequency feature of Schmitt in the process of Liu did not have a reasonable expectation of success at the time Appellants' invention was made. Moreover, as pointed out above, absent Appellants' disclosure, there is no objective teaching to combine Liu and Schmitt as proposed in the final Official Action.

C. **Requirement of Substantial Redesign and Reconstruction Renders Prior Art Combination Improper**

A proposed combination of references is improper under 35 U.S.C. § 103 where the combination "would require a substantial reconstruction and redesign of the elements shown in [the base reference] as well as a change in the basic principles under which [the base reference] construction was designed to operate." *In re Ratti*, 270 F.2d 810, 813, 123 USPQ 349, 352 (CCPA 1959).

In light of the disclosure in Hoffman, it is respectfully submitted that the proposed modification of the MERIE reactor of Liu is improper as the combination would require a substantial reconstruction and redesign of the MERIE reactor of Liu as well as a change in the basic principles under which the MERIE reactor of Liu was designed to operate. Because the quartz gas distribution plate of Liu may not be connected to a high frequency source as disclosed by Schmitt, it would be necessary to replace the quartz plate of Liu with a showerhead electrode. This would result in substantial reconstruction and redesign of Liu's reactor introducing problems addressed in the later filed and subsequently issued Hoffman patent. Accordingly, the modification of Liu proposed in the final Official Action is improper.

D. **The Claimed Structure Affects the Method Steps of Independent Claims 1, 24, and 25**

The Advisory Action contends that "apparatus limitations do not have weight in [a] process claim, unless they affect the process in a manipulative sense." (Advisory Action at Page 2). It is well established that patentability of a method claim can be based on the structure used, if the structure affects the method steps. *Leesona Corp. v. United States*, 185 USPQ 156, 165 (Ct. Cl. Trial Div. 1975).

The presently claimed capacitively coupled plasma reactor and showerhead electrode affect the method steps of independent Claims 1, 24, and 25, demonstrated by recitation of supplying RF energy "at two different frequencies to either the bottom electrode or at different first and second frequencies to the showerhead electrode and bottom electrode." Additionally, Claim 1 recites "supplying an etchant gas to the plasma etch chamber with the showerhead electrode" and "etching openings in the dielectric layer by energizing the etchant gas into a plasma state by capacitively coupling RF energy into the plasma etch chamber." It is respectfully submitted that these recited features must be given weight in the determination of the patentability of independent Claims 1, 24, and 25.

E. **Teachings Away Renders Prior Art Combination Improper**

A prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984); MPEP § 2141.02.

Liu teaches away from the claimed pressure and temperature of independent Claims 1, 24, and 25. The final Official Action asserts that pressure and temperature

> "are recognized result-effective variables, and commonly determined by routine experiment. The process of conducting routine experimentations so as to produce an expected result is obvious to one of ordinary skill in the art. In the absence of showing criticality or new, unexpected results, it is the examiner's position that a person having ordinary skill in the art at the time of the claimed invention would have found it obvious to modify Liu by performing routine experiments ... to obtain

> optimal result in order to produce the best etched product achievable." (Final Official Action at Page 4).

1. **Pressure**

Liu teaches that "the chamber pressure should be no more than 40 milliTorr." (Column 11, Lines 45-47). Therefore, since Liu teaches an upper limit of 40 mTorr for a chamber pressure, and as independent Claims 1, 24, and 25 recite a pressure in a plasma etch reactor of 50 to 100 mTorr, which is clearly greater than Liu's upper limit of 40 mTorr, it is respectfully submitted that Liu teaches away from the presently claimed pressure of 50 to 100 mTorr.

The final Official Action asserts,

> "In an example of obtaining high oxide etch rate, Liu states that the pressure should [be] no more than 40 mT, it is simply an example under a given particular product requirement. In fact, Liu teaches that the chamber pressure may be varied from 25mT to 70 mT, which overlaps the claimed range." (Final Official Action at Page 6).

However, rather than teaching that the chamber pressure may be varied from 25 to 70 mTorr, Liu tested oxide etch rate and photoresist selectivity from 25 to 70 mTorr and concluded, "Clearly, operation at the lower pressure is desired for both oxide etch rate and photoresist selectivity." (Column 11, Lines 42-44). More specifically, Liu determined that for both high oxide etch rate and high photoresist selectivity, "the chamber pressure should be no more than 40 mTorr." (Column 11, Lines 45-50).

Accordingly, it is respectfully submitted that Liu teaches lowering pressure to obtain the desired oxide etch rate and photoresist selectivity, thus leading a person having ordinary skill in the art away from the claimed process wherein the chamber pressure is 50 to 100 mTorr. Such high pressures lead to undesired results in the Liu process. Because Liu specifically teaches a chamber pressure of no more than 40 mTorr, after testing pressures in the range of 25 to 70 mTorr, the rejection should be reversed.

2. **Temperature**

Additionally, Liu states that "fluid cooling channels through the pedestal 38 maintain the pedestal at reduced temperatures." (Column 4, Lines 14-16). Liu discloses that "MERIE plasmas tend to produce a significantly lower electron temperature, thereby reducing the charging effect" (Column 6, Lines 34-36) and the only disclosed cathode temperatures in Liu are -20°C in each of Liu's examples (Columns 8-10, Tables 1-4). Liu does not teach varying temperature to achieve any process result. Thus, there is no suggestion in Liu to raise the pedestal temperature above -20°C to optimize etching results. As such, it is respectfully submitted that the final Official Action fails to establish temperature as a result effective variable and further, there is no suggestion in Liu to maintain the temperature of the substrate support above -20°C and absolutely no suggestion to raise the substrate temperature to between 20°C and 60°C, as recited in Claims 1, 24, and 25.

II. **Rejection of Dependent Claims 2, 3, 8, 11, 12, 14, 18, 19, and 21 under 35 U.S.C. § 103(a)**

A. **Rejection of Claims 3, 19, and 21 under 35 U.S.C. § 103(a)**

Claim 3 recites the method of Claim 1, wherein the stop layer is silicon nitride and the etch rate selectivity of the dielectric to the silicon nitride is at least 10. Claim 19 recites the method of Claim 1, wherein the etched openings open onto flat and corner portions of the stop layer, the dielectric layer comprises BPSG and the stop layer comprises silicon nitride, the etch rate selectivity of the BPSG to the flat and corner portions of the silicon nitride being at least 15. Claim 21 recites the method of Claim 1, wherein the etch rate selectivity of the dielectric to the stop layer is greater than 30:1.

The final Official Action asserts,

> "Dependent claims 3, 19 and 21 differ from Liu by specifying various etching selectivities. However, the skilled artisan recognizes that in plasma etching, changing the flow rates of etchants and the power change the plasma densities and fluxes, and ion energy, and change the etching properties and etching selectivity. Hence, it would have been obvious to one with ordinary skilled in the art to vary the flow rates of etchants and

> process parameters in order to produce desired etch rate selectivity." (Final Official Action at Page 3).

While Liu discloses that the capability to control the composition and conformal deposition of polymeric photoresist improves the selectivities to the underlayers made of materials other than $SiO_2$, such as $Si_3N_4$, polysilicon, and metal silicide, Liu is ultimately concerned with providing high selectivity for etching oxide relative to photoresist. (Column 4, Line 55 - Column 5, Line 6). Thus, Liu discloses a photoresist selectivity, measured as the ratio of (1) the oxide thickness etched through plus a distance correspond to the over-etch time used to (2) the depth of the lower photoresist facet corner from the original photoresist surface, as large as greater than 10:1 (Column 9, Lines 9-15).

Accordingly, it is respectfully submitted that Liu in view of Schmitt does not disclose or suggest a process that achieve the presently claimed etch rate selectivity of dielectric to silicon nitride of at least 10 (Claim 3), etch rate selectivity of BPSG to flat and corner portions of silicon nitride of at least 15 (Claim 19), or etch rate selectivity of dielectric to stop layer of greater than 30:1 (Claim 21). As such, the rejection of Claims 3, 19, and 21 should be reversed.

B. **Rejection of Claims 8 and 14 under 35 U.S.C. § 103(a)**

Claim 8 recites the method of Claim 1, wherein the $C_xF_y$ gas is at least $C_4F_6$, the oxygen containing gas is at least $O_2$ and the carrier gas is Ar, the etchant gas being supplied to the plasma etch reactor through the showerhead electrode at flow rates of 10 to 25 sccm $C_4F_6$, 5 to 20 sccm $O_2$ and 50 to 300 sccm Ar. Claim 14 recites the method of Claim 1, wherein the etchant gas includes CO supplied to the plasma etch reactor at a rate of 50 to 500 sccm CO.

Similar to pressure and temperature as noted above, the final Official Action asserts that etchant flow rates

> "are recognized result-effective variables, and commonly determined by routine experiment. The process of conducting routine experimentations so as to produce an expected result is obvious to one of ordinary skill in the art. In the absence of showing criticality or new, unexpected results, it is the examiner's position that a

person having ordinary skill in the art at the time of the claimed invention would have found it obvious to modify Liu by performing routine experiments ... to obtain optimal result in order to produce the best etched product achievable." (Final Official Action at Page 4).

1. **Claim 8**

Liu discloses: (1) a $C_4F_6$ flow of 30 SCCM, an $O_2$ flow of 18 SCCM, and an Ar flow of 700 SCCM (Table 1), (2) a $C_4F_6$ flow of 30 SCCM, an $O_2$ flow of 23 SCCM, and an Ar flow of 700 SCCM (Table 2), (3) a $C_4F_6$ flow of 28 SCCM, an $O_2$ flow of 24 SCCM, and an Ar flow of 500 SCCM in Step 1 and a $C_4F_6$ flow of 28 SCCM, an $O_2$ flow of 20 SCCM, and an Ar flow of 500 SCCM in Step 2 (Table 3), and (4) a $C_4F_6$ flow of 23 SCCM, an $O_2$ flow of 18 SCCM, and an Ar flow of 500 SCCM (Table 4). Specifically, Liu discloses, "The flow of argon relative to that of hexafluorobutadiene[5] is high, at least ten times greater and preferably twenty times greater." (Column 10, Lines 28-30). Accordingly, in view of Liu's desire to use high Ar flow rates and lack of any teaching to use 300 SCCM or lower Ar flow rate, it is respectfully submitted that Liu in view of Schmitt does not disclosure or suggest the presently claimed flow rates of 10 to 25 sccm $C_4F_6$, 5 to 20 sccm $O_2$ and 50 to 300 sccm Ar.

2. **Claim 14**

While Liu discloses inclusion of CO in the etching gas mixture, Liu does not disclose the flow rate at which CO may be added. For example, Liu simply discloses, "The invention includes a process for etching dielectric oxides in a capacitively coupled plasma etch reactor using a heavy fluorocarbon such as hexafluorobutadiene ($C_4F_6$), oxygen, and a substantial fraction of a carrier gas, preferably argon. Carbon dioxide (CO) may additionally be added." (Column 4, Lines 55-59). Liu additionally discloses, "[I]t is often desirable to combine the beneficial effects of a low-F/C fluorocarbon and a high carrier gas fraction with a polymer-oxidizing gas, such as gaseous oxygen ($O_2$) or carbon monoxide (CO)." (Column 5, Line 65 – Column 6, Line 2). Accordingly, because Liu fails to suggest

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[5] $C_4F_6$

adding 50 SCCM or more CO, it is respectfully submitted that there is no teaching in Liu which would have lead a person of ordinary skill in the art to supply CO at a rate of 50 to 500 sccm CO.

C. **Rejection of Claims 2, 11, and 12 under 35 U.S.C. § 103(a)**

Claim 2 recites the method of Claim 1, wherein the openings comprise vias, contacts, and/or trenches of a dual damascene structure, a self-aligned contact structure or self-aligned trench structure and the showerhead electrode is supplied 0 to 3000 watts of RF energy and the bottom electrode is supplied 0 to 3000 watts of RF energy. Claim 11 recites the method of Claim 1, wherein the dual frequency capacitively coupled plasma reactor is operated with a top electrode power of 200 to 3000 W and a bottom electrode power of 50 to 3000 W for etching the openings. Claim 12 recites the method of Claim 1, wherein the dual frequency capacitively coupled plasma reactor is operated with a top electrode power of 1000 to 2000 W, and a bottom electrode power of 1000 to 2000 W for etching the openings.

Similar to pressure, temperature, and etchant flow rates as noted above, the final Official Action asserts that RF energy is a recognized result-effective variable,

> "commonly determined by routine experiment. The process of conducting routine experimentations so as to produce an expected result is obvious to one of ordinary skill in the art. In the absence of showing criticality or new, unexpected results, it is the examiner's position that a person having ordinary skill in the art at the time of the claimed invention would have found it obvious to modify Liu by performing routine experiments ... to obtain optimal result in order to produce the best etched product achievable." (Final Official Action at Page 4).

Liu discloses supplying power to the pedestal and there is no upper electrode in Liu since the showerhead is made of quartz. (See, for example, Column 11, Lines 32-35). While Schmitt discloses various plasma reactors, Schmitt fails to disclose the claimed electrode power. It is respectfully submitted that Liu in view of Schmitt does not disclose or suggest modifying Liu to include a showerhead electrode and supplying the showerhead electrode 0 to 3000 watts of RF energy and the bottom electrode 0 to 3000 watts of RF energy, operating with a top electrode power of 200

to 3000 W and a bottom electrode power of 50 to 3000 W, or operating with a top electrode power of 1000 to 2000 W and a bottom electrode power of 1000 to 2000 W.

D. **Rejection of Claim 18 under 35 U.S.C. § 103(a)**

Claim 18 recites the method of Claim 1, wherein the $C_xF_y$ is $C_4F_6$ and the oxygen containing gas is supplied to the plasma etch chamber in an amount sufficient to avoid etch stop during etching of the openings.

The Official Action mailed August 30, 2004, asserts that "[a]s to dependent claim 18, in order to complete the etching of the openings, keeping an amount of etchants sufficient to avoid etch stop is expected in the method of Liu." (Official Action Mailed August 30, 2004, at Page 4). Liu discloses that during fluorocarbon etching of holes in oxide, too little polymerization will degrade protection to the sidewall and selectivity to photoresist, nitride, and other non-oxide materials, while a slight excess of polymerization in very high aspect-ratio holes will cause etch stop towards the bottom of the hole. (Column 5, Lines 24-35). Liu discloses that an amount of argon at least 10 times that of $C_4F_6$, preferably at least 20 times will help increase the etch stop margin. (Column 9, Lines 2-4).

In contrast, the present application specifically discloses that polymer build-up can be reduced by the synergistic effect of breaking up polymer with oxygen in the etching gas mixture. (Present Application at Page 18, Line 1-11). Thus, oxygen is added in an amount effective to control the etch rate selectivity of the etching gas chemistry. That is, the oxygen is effective to prevent etch stop by reacting with polymer at the bottom of the etched openings. (Present Application at Page 18, Line 12-15). Liu fails to teach the process recited in Claim 18.

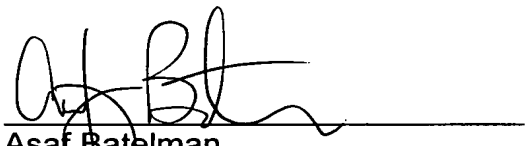
III. **Conclusion**

In view of the forgoing and for the reasons set forth in the Appeal Brief, it is submitted that all rejections set forth in the Examiner's Answer are untenable and should be reversed.

Two extra copies of this Reply Brief are being filed herewith. No fee is believed to be due, however, the Commissioner is authorized to charge any fees that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800.

Respectfully submitted,

Burns, Doane, Swecker & Mathis, L.L.P.

Date: 10/21/05 By: 

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